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By

ROBERT MCKAY, D.Sc., and PHYLLIS E. M. CLINCH, D.Sc.

Department of Plant Pathology, University College, Dublin.

Plates 7 and 8.

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In a previous paper (3) the authors have shown that the two potato varieties, Shamrock and Skerry Champion, although very resistant to Leaf Roll infection in the field, are by no means immune to the disease, as it can be readily transmitted to each variety both by grafting and through sprout infection by means of aphides. Neither can either variety be considered a carrier of Leaf Roll, as after infection Skerry Champion shows unmistakable rolling of the lower leaves, which is so characteristic a feature of the disease; and in Shamrock, though rolling of the foliage is not so obvious, it does occur to some extent in the early stages of growth, and diseased plants are reduced in size and vigour, and have a slightly chlorotic appearance. No explanation of the field resistance of these varieties is as yet forthcoming, and in the case of Skerry Champion this resistance amounts almost to field immunity. Such a factor is obviously of the greatest importance, and if it could be bred into modern commercial potato varieties it would go far in preventing the spread of Leaf Roll.

The present paper deals mainly with the inheritance of this resistance, the observations being made on the progeny of a cross between Shamrock and Skerry Champion. Shamrock was the pollen parent, and the cross was made in 1944 by Mr. John Clarke, the well-known County Antrim potato breeder, to whom the authors are indebted for supplying tubers of the various units. There were 22 of these, all of which were derived from a single berry.

Before recording the observations, a few facts regarding the original parents will not be out of place, and they are more or less necessary for a clear understanding of what follows.

SHAMROCK.

Tuber—Round, somewhat flattened, dented at stem end: eyes medium to deep, eyebrow present: skin uniformly deep pink: flesh white with occasional traces of pink under skin at the rose end. Sprout deep pink.

Foliage—Haulm erect, medium height, strong, branching, largely mottled reddish-purple. Leaf very open, midrib dark reddish-purple, often showing in two lines on young leaves: leaflets rather small, dark green on long petioles.

Flower—White, large, numerous, persistent; occasional tinge of reddish-purple on back of petals: anthers orange, regular, pollen abundant: buds dark reddish-purple; drooping; flower peduncle long, as are the flower stalks.

Maturity—Very late maincrop. Berries frequently produced in certain years.

Shamrock is not grown to any extent as a field crop in Ireland, but small lots of it are found in various localities. The yield is good, quality medium, and tubers keep well. The variety is immune to Wart Disease *(Synchytrium endobioticum)*, and it is very resistant to Blight *(Phytophthora infestans)* in both foliage and tubers. It is tolerant of viruses Y, X, A, F, and G, on infection with which it shows the following symptoms:—

Virus Y—Mottle, rugosity, and leaf drop.

,, X—Mild mottle to severe mottle accompanied by necrotic lesions according to strain.

,, A—Mild mottle in foliage.

,, F—Slight yellow spotting and wilting of tips of lower leaves. Necrosis in parenchymatous tissue of tubers.

,, G—Acuba Mosaic mottle in lower leaves. Slight necrosis in parenchymatous tissue of tubers.

Virus X + Y—Rugose Mosaic.

,, X + A—Crinkle.

Davidson (1) states that Shamrock is probably more resistant to potato diseases generally than any other known variety.

SKERRY CHAMPION.

(Synonyms.—Sriped Champion and Buchan Beauty.)

Tuber—Round, irregular: eyes deep, eyebrow distinct: skin yellowish, with light blue purple splashes, frequently in bands around the tuber, amount of colouring is variable: flesh yellow, hard, firm. Sprout purple.

Foliage—Haulm erect, tall, vigorous, strong; stems numerous, branching; develops little colour except at the nodes: wing waved at the top. Leaf stiff, erect, fairly open, usually no colour in midrib, but frequently a dark spot in axil of leaflet stalk: a deep groove in the midrib causes the sides to show up as two green lines, occasionally coloured: leaflets yellowish green, dull, margins wavy, medium size: young growth sulphury: secondary leaflets small and rounded, numerous, occurring sometime on stalks of the leaflets.

Flower—Deep blue purple, large, numerous; tips of petals almost white: anthers yellow, pollen poorly developed: purple band on style: buds deep bluish purple: flower peduncle long, mottled, blue purple: pedicels long, deeply coloured, sometimes bearing small leaflets.

Maturity—Maincrop.

Skerry Champion is a popular variety which is cultivated fairly extensively throughout the Midlands of Ireland. The quality is exceptionally good. The variety is immune to Wart Disease *(Synchytrium endobioticum)*, but is rather susceptible to Blight *(Phytophthora infestans)*. No virus-free plants of Skerry Champion have yet been found. Its reactions to the common viruses are similar to those of Shamrock.

There is no information regarding the origin of either variety.

Field Experiments on Leaf Roll Infection in Progeny of Shamrock X Skerry Champion.

1946 Experiment. Only single tubers of each of the 22 seedling units were available for trial in 1946. These tubers were planted in alternation with tubers of Kerr's Pinks infected with Leaf Roll. Six tubers of healthy Arran Cairn were similarly planted as controls, and all setts were 18 inches apart. At the end of the growing season 6 tubers were saved from each plant and these were planted in the field in 1947 for observation. The amount of Leaf Roll infection contracted in 1946 is shown in Column A of Table I. It will be seen that 7 of the 22 units became infected, but in the case of unit 2 only one of the 6 tubers gave rise to a Leaf Roll plant. Under the same conditions the control variety had become 100 per cent. Leaf Roll.

1947 Experiment. During the 1947 season the plants which had failed to contract Leaf Roll in 1946 were again exposed to infection, as each was grown in alternation with a Leaf Roll Kerr's Pink plant. There were thus 6 plants of each of 15 units and 5 of unit 2 exposed to Leaf Roll in the 1947 experiments. The controls on this occasion consisted of 6 tubers, respectively, of each of the varieties, President, Shamrock, and Skerry Champion. At the end of the growing season, 6 tubers from each of the experimental plants were saved and planted for observation in 1948. The results are shown in Column B of Table I. It is seen from this that only one of the 95 experimental plants belonging to the seedling units, *i.e.*,

unit 7, contracted infection during 1947. Conditions during the latter year were obviously not favourable for the spread of Leaf Roll, as only 50 per cent. infection occurred in the highly susceptible variety, President, used as one of the controls.

1948 Experiment. In the spring of 1948 a further supply of tubers of the seedling units was received from Mr. Clarke, which enabled a fresh trial to be made. Accordingly, 6 tubers of each unit were planted in the field in alternation with tubers of Kerr's Pink infected with Leaf Roll. Controls were similarly planted, and in this case they consisted of 12 healthy Presidents and 12 healthy Kerr's Pink, the former variety representing a highly susceptible one, and Kerr's Pink one of medium susceptibility. The entire produce of each experimental plant was saved at the end of the growing season, and these tubers were planted in the field in 1949 for observation. The results of this experiment appear in Column C of Table I. Only 3 units (Nos. 10, 14 and 16) escaped infection completely. The remaining units of Mr. Clarke's material were infected in varying degrees, but it may be noted that those which showed 100 per cent. infection included the 6 units which had succumbed in the original test in 1946, *viz.*, Nos. 4, 5, 6, 17, 20, and 22. It is obvious that the 1948 growing season, in contrast to that of 1947, was extremely favourable for spread of Leaf Roll, and all control plants contracted infection to extent of 100 per cent.

During the course of these experiments the possibility was considered of plants apparently healthy in the field being carriers of Leaf Roll. Scions were therefore taken from a number of plants, particularly of units 10, 14, and 16, and were grafted on Presidents in the glasshouse, the produce being planted out the following year. All plants diagnosed as healthy in the field and tested in this manner proved to be free of Leaf Roll.

Sprout Infection Experiment.

As many of the seedling units escaped infection in 1947, it was considered desirable to ascertain whether any unit possessed true immunity to Leaf Roll, or whether the phenomenon was of the type shown by the parents Shamrock and Skerry Champion, and termed field immunity. In the spring of 1949, therefore, 6 tubers of each of the 22 seedling units were exposed to infection with viruliferous aphides. The sprouting tubers were placed in a cage in the greenhouse together with a large plant of British Queen infected with Leaf Roll and infested with *Myzus persicae*. As controls, 6 sprouting tubers of healthy Arran Consul and 6 healthy British Queen were included. The sprouts soon became infested with aphides from the Leaf Roll source, as many winged forms were present. After 10 days' exposure the tubers were fumigated and planted out in the field. The majority of the seedling units showed 100 per cent. Leaf Roll infection in the current season, and no unit escaped. It is clear, therefore, that none of the seedling units possessed true immunity, though some are highly resistant under field conditions. The control varieties in this experiment developed Leaf Roll to extent of 100 per cent.

TABLE I.

Leaf Roll Infection in Progeny of Shamrock x Skerry Champion

	A Results in 1947 showing amount of infection in produce of single plants exposed to Leaf Roll in 1946.		B Results in 1948 showing number of plants which became infected out of those in each unit exposed to Leaf Roll in 1947.		C. Results in 1949 showing number of plants which became infected out of 6 in each unit exposed to Leaf Roll in 1948.	
Seedling Units	Leaf Roll	Healthy	Leaf Roll	Healthy	Leaf Roll	Healthy
1	0	6	0	6	2	4
2	1	5	0	5	3	3
3	0	6	0	6	4	2
4	6	0	–	–	6	0
5	4	2	–	–	6	0
6	5	1	–	–	6	0
7	0	6	1	5	6	0
8	0	6	0	6	5	–
9	0	6	0	6	6	0
10	0	6	0	6	0	6
11	0	6	0	6	1	5
12	0	6	0	6	5	1
13	0	6	0	6	5	1
14	0	6	0	6	0	6
15	0	6	0	6	2	4
16	0	6	0	6	0	6
17	6	0	–	–	6	0
18	0	6	0	6	6	0
19	0	6	0	6	5	1
20	6	0	–	–	6	0
21	0	6	0	6	1	4
22	6	0	–	–	6	0
Controls:						
Arran Cairn ...	36	0	–	–	–	–
President ...	–	–	3	3	12	0
Shamrock ...	–	–	0	6	–	–
Skerry Champion	–	–	0	6	–	–
Kerr's Pink ...	–	–	–	–	12	0

Variations in Reaction to Leaf Roll in Seedling Units.

Apart altogether from the amount of infection contracted by the experimental units, it was interesting to note the variations in symptoms of disease displayed by the different units. Were these variations shown haphazardly by members of any single unit following field infection, then one would have concluded that different strains of Leaf Roll were present. However, all plants of each unit reacted consistently to the virus throughout the field trials. Furthermore, in the sprout infection experiment all units were infected from the same source, and the subsequent symptoms agreed with those resulting from natural infection in the field.

The units could be classified into four broad groups, as shown below, and referred to well-known potato varieties as representative of each group. The units in each group are placed in order of descending severity; one group grading into another.

Group (i). The most severely affected unit was No. 20, see Fig. 1, Plate 7. Plants here were reduced in size and vigour by two-thirds, the unit being totally unrecognizable. There was severe chlorosis and dwarfing, the leaflets reduced in size, and a considerable development of reddish pigment. All units in this group could be referred to the President type of Leaf Roll, or worse.

Group (ii). In this group the reduction in size and vigour varied from one-half to one-third, Figs. 2 and 3, Plate 7. Some slight chlorosis was occasionally present, and the disease ranged from fairly severe to moderate, but all plants obviously Leaf Roll. The type of disease here would be that shown by such varieties as Kerr's Pink or Majestic.

Group (iii). Very little reduction, if any, in size or vigour of the plant. Lower leaves only rolled, Fig. 4, Plate 8. Symptoms would correspond to those shown by Great Scot.

Group (iv). Unit 14 when infected showed the least effect of any. No reduction in size or vigour of the plant, and only an occasional terminal leaflet at the base of the plant rolled, Fig. 5, Plate 8. Shamrock or Matador type of Leaf Roll.

Group i President type of Leaf Roll Units	*Group ii* Kerr's Pink type of Leaf Roll Units	*Group iii* Great Scot type of Leaf Roll Units	*Group iv* Shamrock type of Leaf Roll Units
20	5, 17 7	22	16
4	2, 3, 8	6	11
13	12, 1, 18		14
15	21, 19		
	9, 10		

Internal examination for phloem necrosis was not carried out on these plants.

Notes on Some Additional Characteristics of the Seedling Units.

	Per cent. of units
Skin of tubers	
Reddish or pink	50
Purple splashed	25
White	25
Flesh of tubers	
Cream coloured	48
Yellow	29
White	19
Pink	4
Eyes	
Deep	80
Shallow	20
Immune to Wart Disease	82
Susceptible to Wart Disease	18

Observations on resistance to Blight *(Phytophthora infestans)* were made during the years 1947-1950, the reaction of the units being compared to that of varieties Arran Banner, Arran Victory, Up-to-Date, Majestic, Kerr's Pink and Shamrock grown in the same plots. Unit 1 was the most strongly resistant to Blight, being closely followed in this respect by units 16 and 11. The resistance shown by unit 1 resembled that of its parent, Shamrock. Other units which showed some slight resistance to blight attacks were 21, 14, and 10, these units retaining about half their foliage when commercial varieties and other units in the plots were completely defoliated.

Discussion.

No evidence of true immunity to Leaf Roll of potatoes is forthcoming from these experiments, but there is evidence of inheritance of field resistance to the disease. The exposure to infection to which the 22 seedling units were subjected during the years 1946, 1947 and 1948 was severe, as the unit plants were grown each year in alternation with Kerr's Pink plants infected with Leaf Roll. The surprising thing is that any unit entirely escaped infection under these conditions. However, three units escaped Leaf Roll altogether when exposed to field infection in above manner, and four other units showed some resistance, as they contracted less than 50 per cent. infection when control varieties succumbed to extent of 100 per cent.

Working with mild reactors to Leaf Roll in Australia, Hutton (2) suggests that such plants are unsuitable parents for breeding from on account of the difficulty of diagnosing Leaf Roll in the field. In the Irish experiments described, all potentialities for outward symptoms of the disease were present in the parent plants, Shamrock and Skerry Champion, both of which might be considered as mild reactors. A word of caution, therefore, is necessary with regard to discarding such plants for breeding, as they can give progeny showing severe symptoms of Leaf Roll when infected, and valuable material in respect to other diseases may be thrown away.

Summary.

Observations were made during three years on the inheritance of field resistance to Leaf Roll of 22 seedling units resulting from a cross between the varieties, Shamrock and Skerry Champion. The units were planted alternately with Kerr's Pink plants infected with Leaf Roll, with appropriate controls. The year following the exposure to infection the produce was planted and the amount of Leaf Roll recorded. Under the experimental conditions, three units showed inheritance to field resistance, as they escaped infection completely, and four others contracted less than 50 per cent. infection compared with 100 per cent. in controls. However, no true immunity to Leaf Roll occurred, as all units succumbed to sprout infection by means of aphides.

The symptoms of Leaf Roll displayed by the various units differed considerably, but each unit behaved consistently to infection, whether this occurred naturally in the field or resulted through sprout infection from a single source. The units could be classified into four broad groups as regards external symptoms of the disease.

Group (i). Severe, plants reduced in size and vigour by two-thirds. President type of Leaf Roll.

Group (ii). Reduction in size and vigour by from one-half to one-third that of healthy plants. Kerr's Pink or Majestic type.

Group (iii). Little or no reduction in size or vigour. Lower leaves only rolled. Great Scot type.

Group (iv.) No reduction in size or vigour of the plants, and only an occasional terminal leaflet rolled at base of plant. Shamrock type of disease.

Some notes are recorded on other characteristics of the seedling units.

Explanation of Plates.

All photographs taken at same distance from camera, and all units photographed the year after infection occurred; hence, all plants are secondary Leaf Roll.

Plate 7.

Fig. 1. Leaf Roll in unit 20, severe effects. President type of the disease. Group (i).
Figs. 2 & 3. Leaf Roll in units 7 and 9, respectively; effects fairly severe to medium. Kerrs Pink and Majestic type of the disease. (Group (ii).

Plate 8.

Fig. 4. Leaf Roll in unit 22. Lower leaves only rolled. Great Scot type of the disease. Group (iii).

Fig. 5. Leaf Roll in unit 16. Two apparently normal leaves were removed from the base of the plant so that the rolled leaves became exposed. Shamrock type of the disease. Group (iv).

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Figure 3.

Figure 2.

Figure 1.

Figure 4.

Figure 5.